

IMAGING BY MAGNETIC RESONANCE ADSORPTION, ELASTOGRAPHY  
AND TOMOGRAPHY

RELATED APPLICATIONS

[0001] This application claims benefit of priority to and is a continuation-  
5 in-part of provisional application serial no. 60/414,617 filed September 27, 2002.

FIELD OF THE INVENTION

[0002] This invention relates to magnetic resonance (MR) imaging  
systems and microwave tomography systems. In particular, a system combines MR  
microwave absorption imaging with MR-compatible microwave tomography to  
10 differentiate biological tissues having different electrical properties. These techniques  
may also be combined with data generation in magnetic resonance elastography  
(MRE).

BACKGROUND

[0003] MR elastography (MRE) involves measuring motion resulting from  
15 low frequency vibration. Present MR elastography methods use a separate gradient  
waveform to encode the motion, for example, in context of the Larmor equation that  
is used to measure tissue strain and discussed in United States Patent No. 5,982,828  
issued to Rossman et al. The gradient waveform may be added between the RF  
excitation and the readout of the echo. The resulting increased echo time has the  
20 undesirable effect of decreasing the signal amplitude, as well as increasing the  
imaging time.

[0004] MRE has shown promise in tissue imaging, including breast  
imaging. Several acquisition methods with corresponding reconstruction methods  
have been used to find the shear modulus of tissue in vivo. The first elastographic  
25 methods used ultrasound to measure static and dynamic displacements and the raw  
strain images were interpreted without reconstruction. See J. Ophir et al.,  
"Elastography: A Quantitative Method for Imaging the Elasticity of Biological  
Tissues," Ultrasonic Imaging, 13:111-134 (1991); and K. J. Parker et al., "Tissue  
response to mechanical vibrations for 'sonoelasticity imaging,'" Ultrasound Med. Biol.  
30 16(3):241-6 (1990). The first MR elastographic method measured the local

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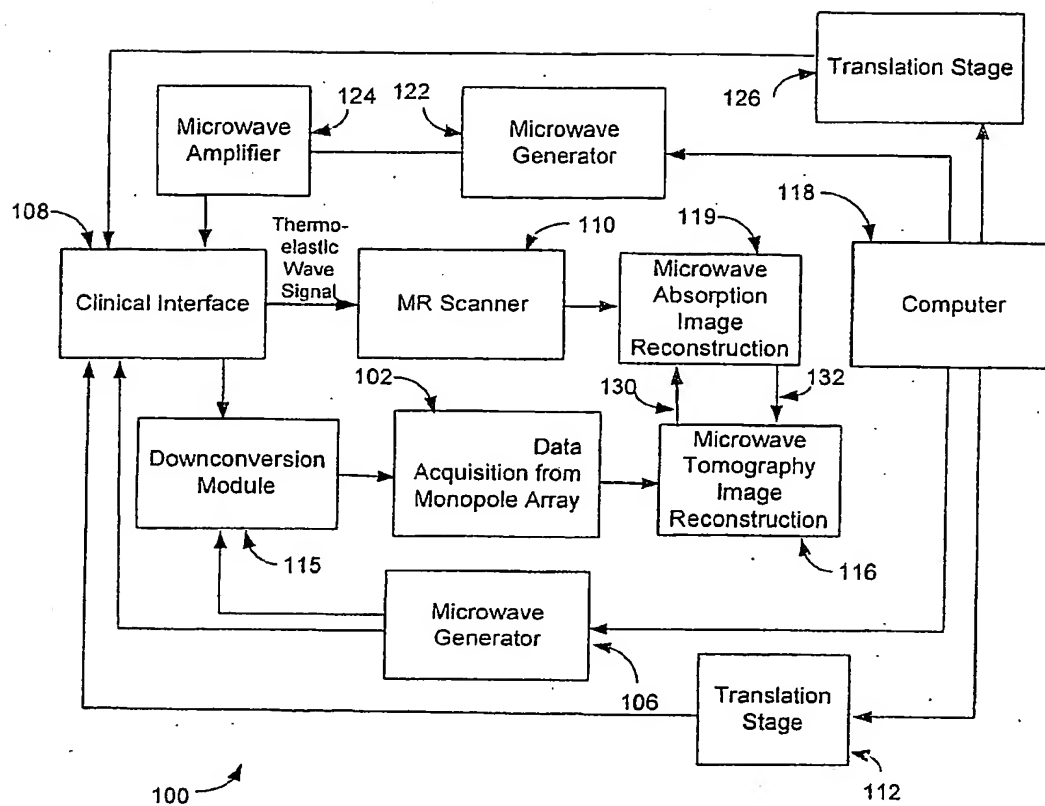


FIG. 1

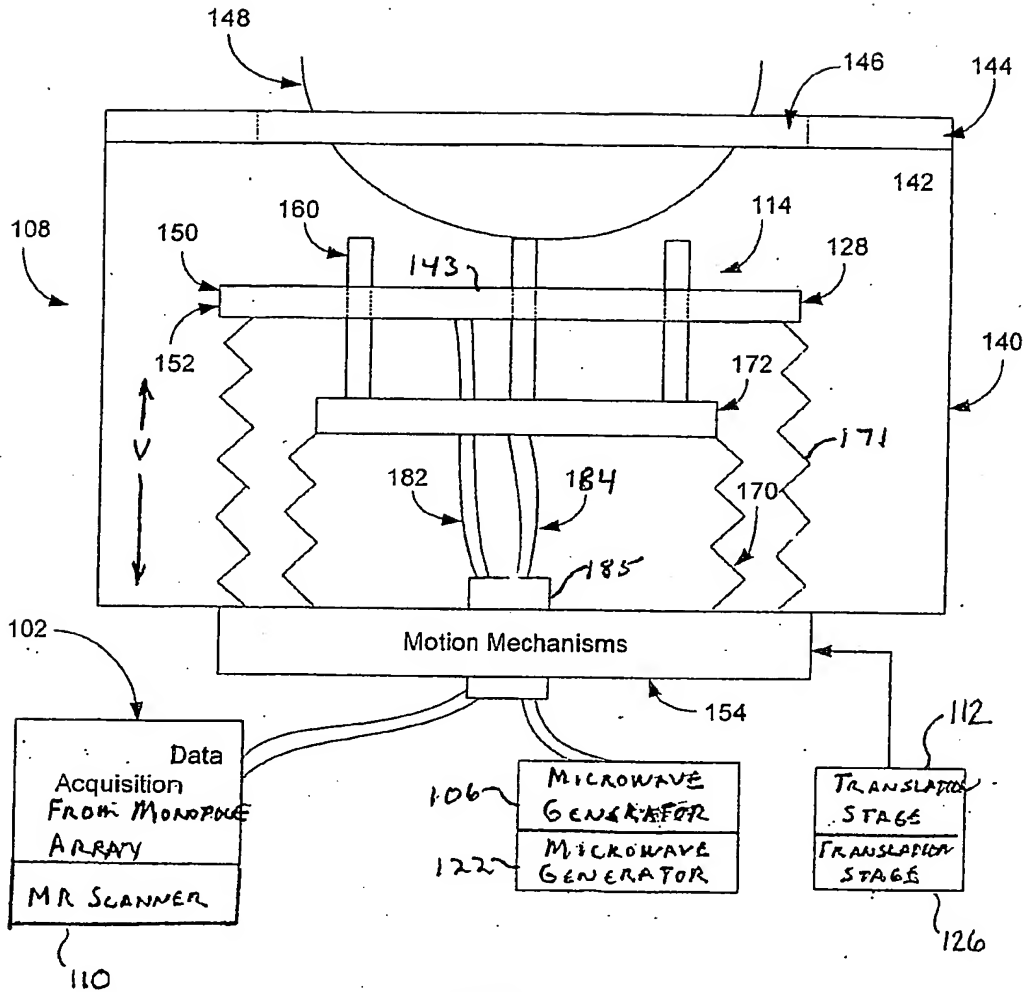


FIG. 2

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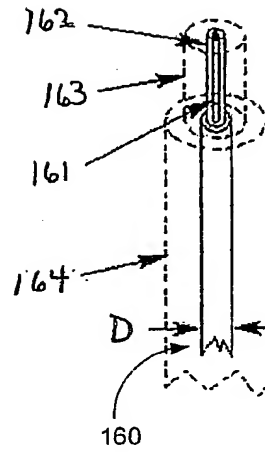


FIG. 3

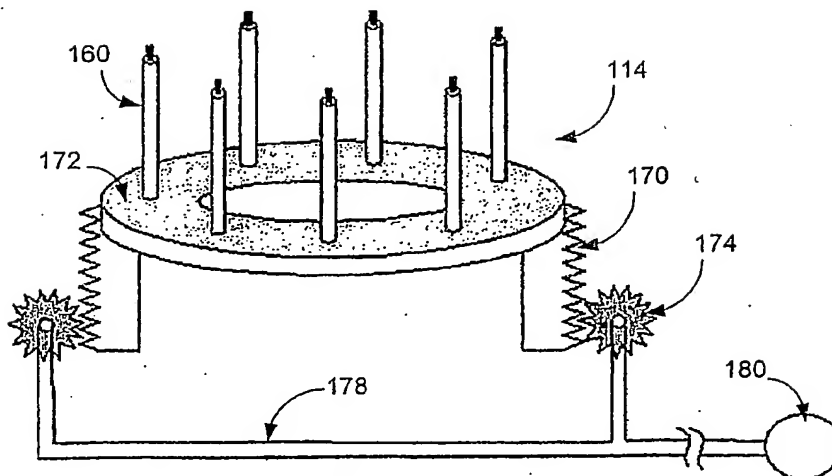


FIG. 4

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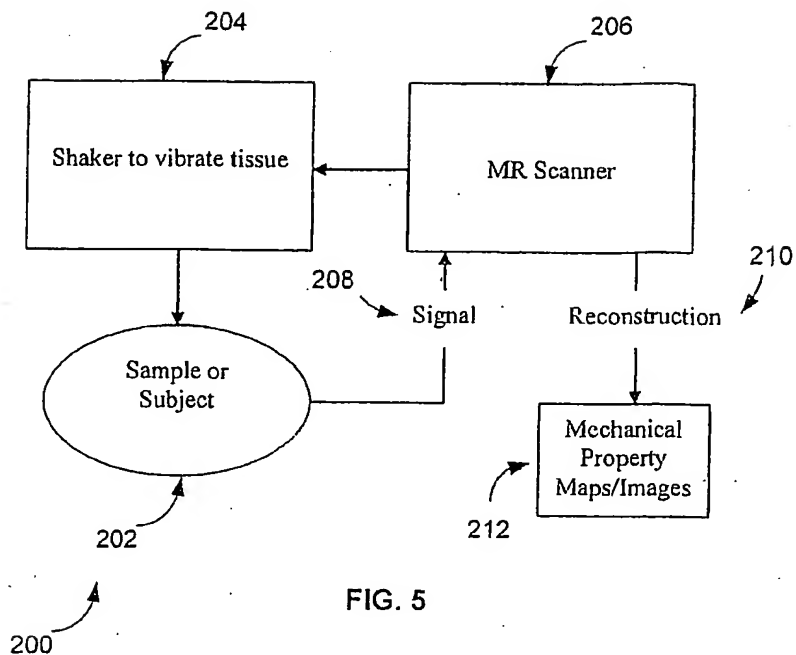


FIG. 5

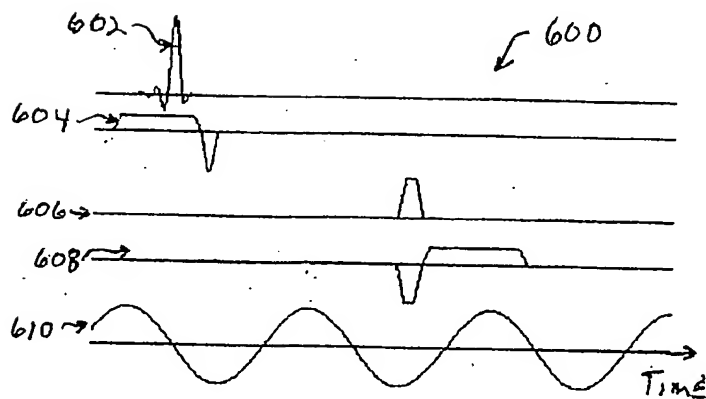


FIG. 6A

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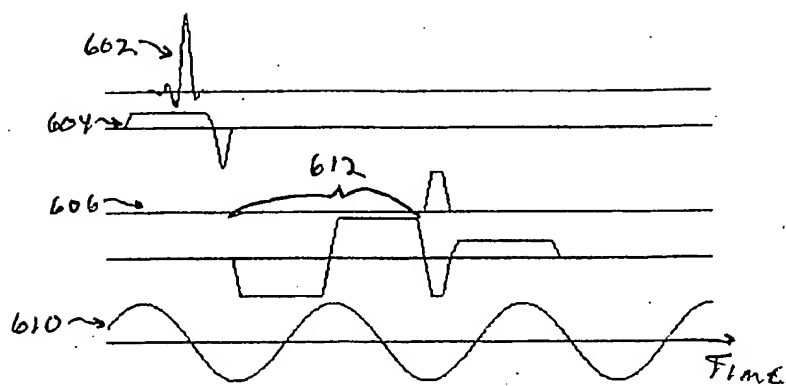


FIG. 6B

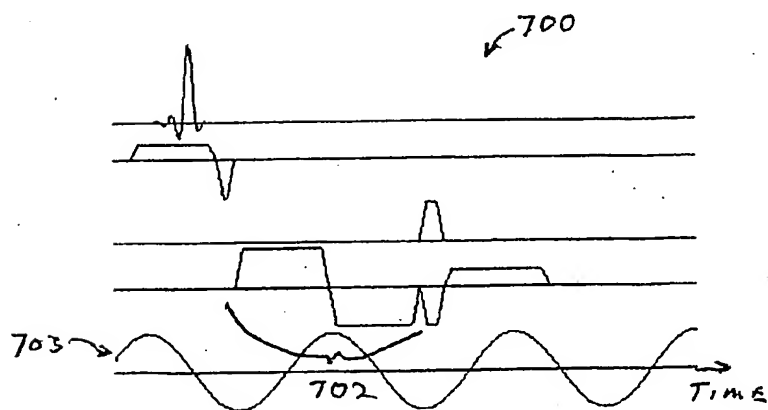


FIG. 7A

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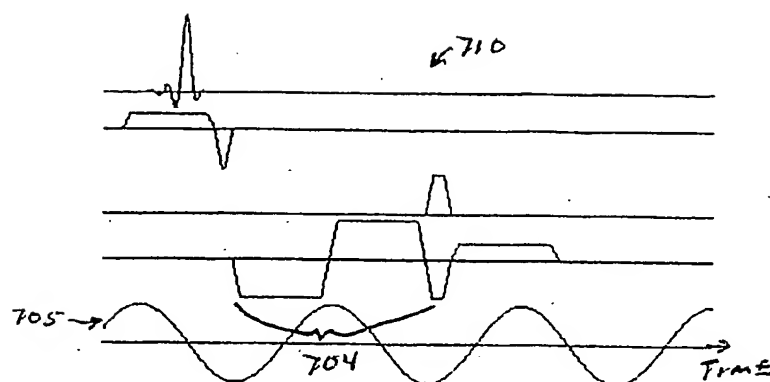


FIG. 7B

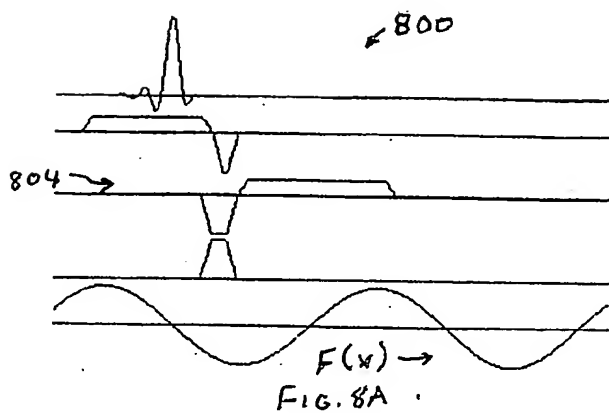


FIG. 8A

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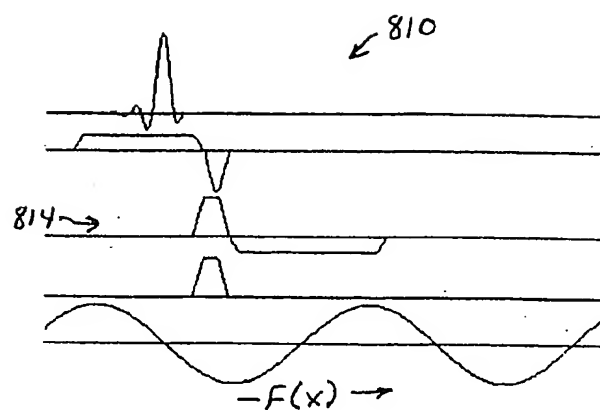


FIG. 8B

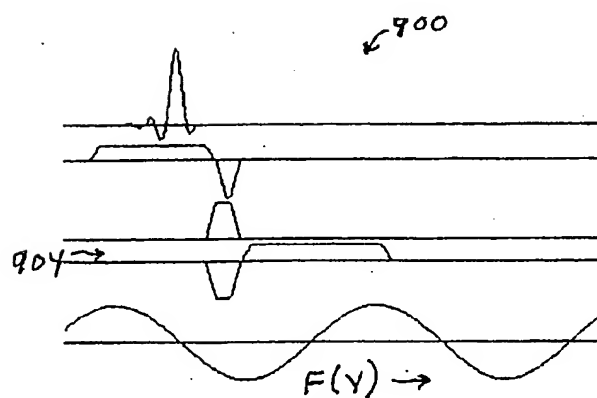


FIG. 9A



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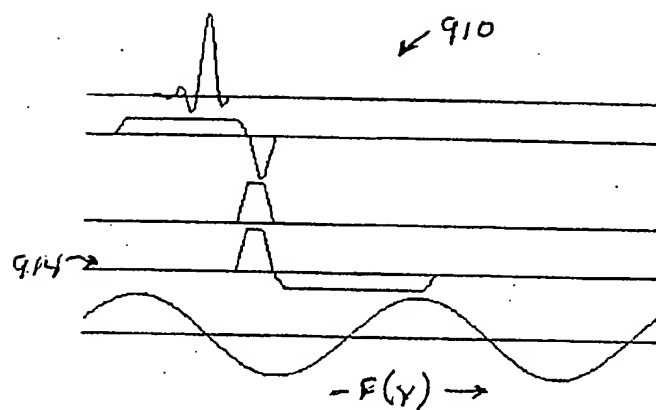


FIG. 9B

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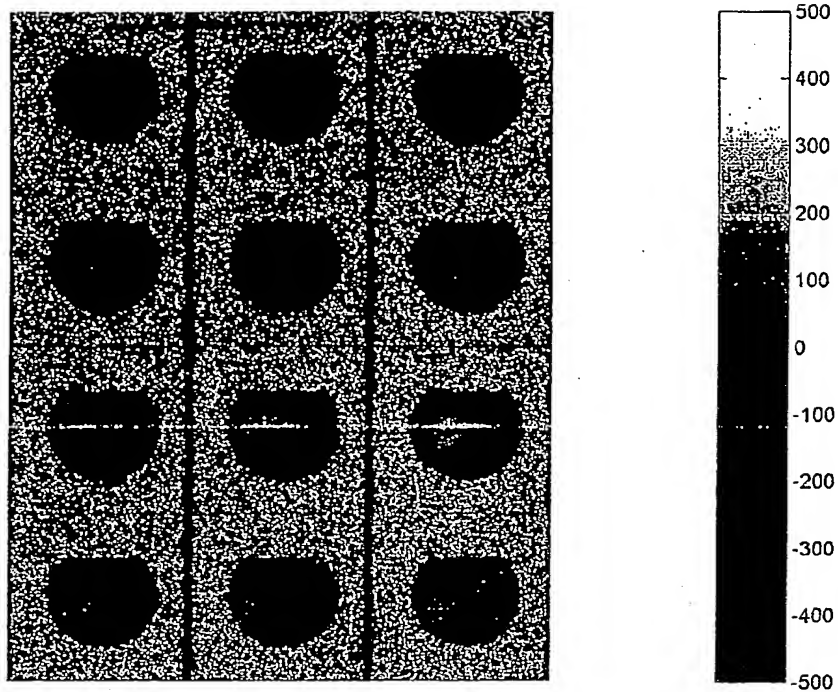


FIG. 10

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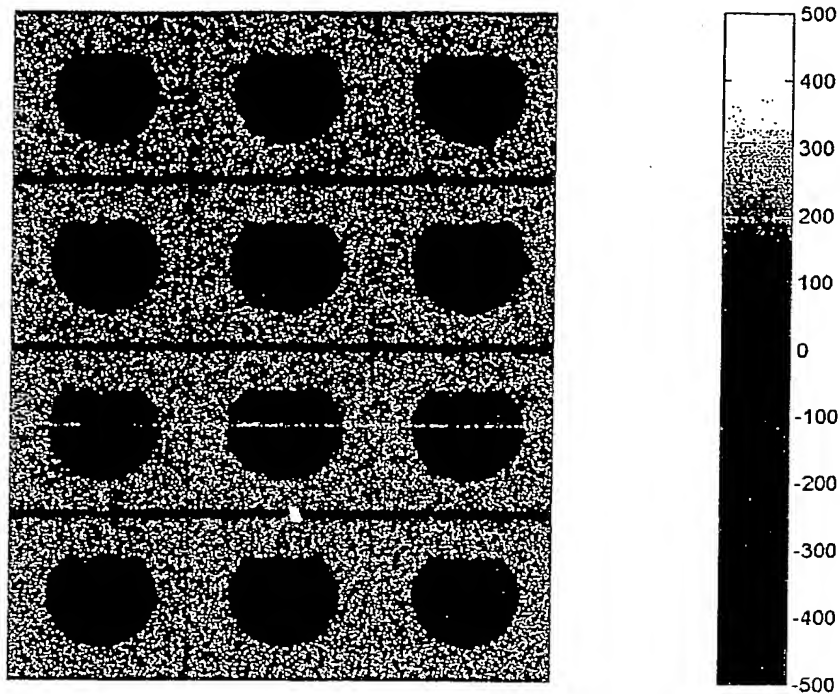


FIG. 11